W. K. SIMPSON.

VAPOR HEATING SYSTEM.

APPLICATION FILED MAR. 31, 1921.

1,408,478.

Patented Mar. 7, 1922.

2 SHEETS—SHEET 1.

Fig. 1.

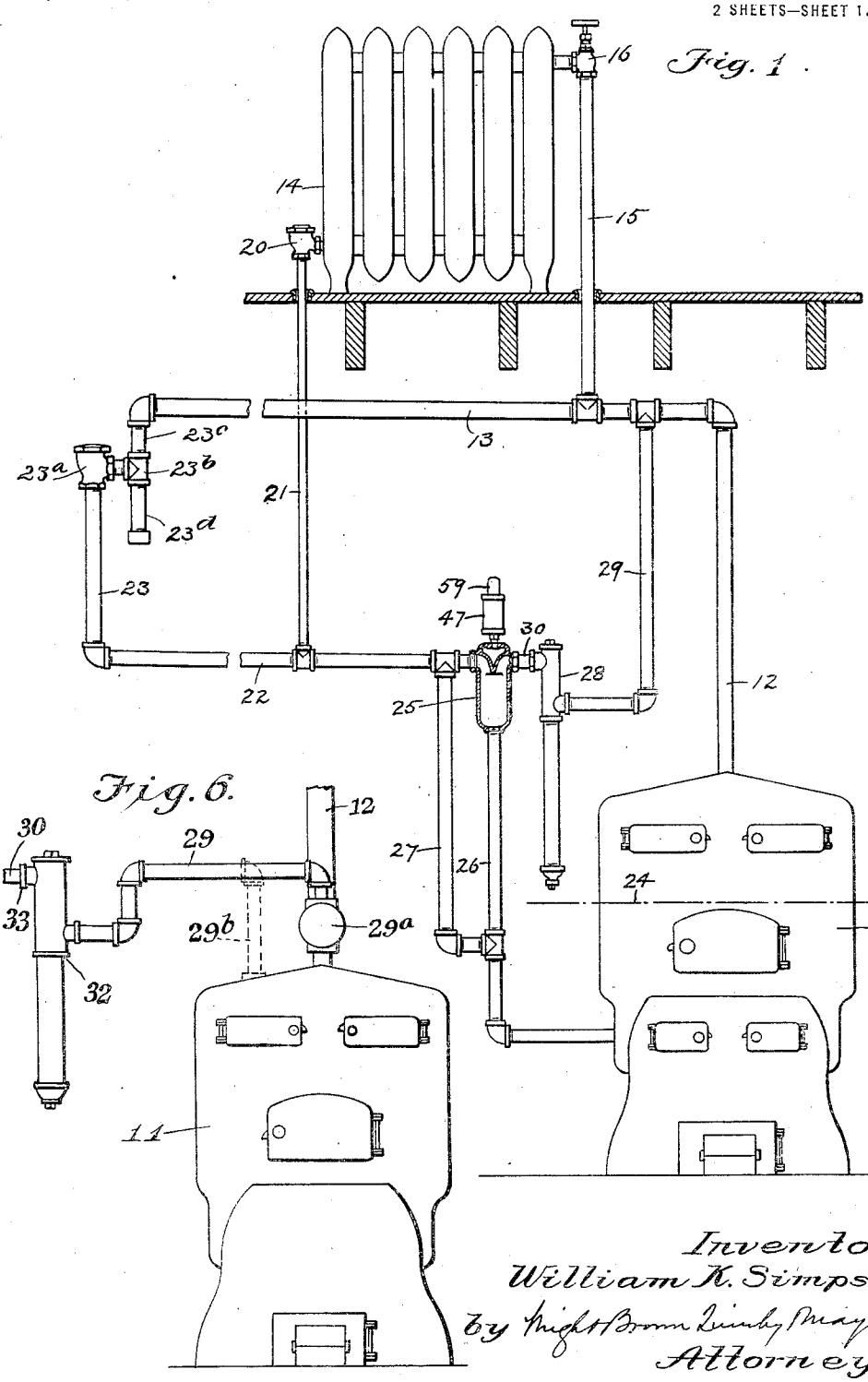

Fig. 6.

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2 SHEETS—SHEET 2.

Fig. 5.

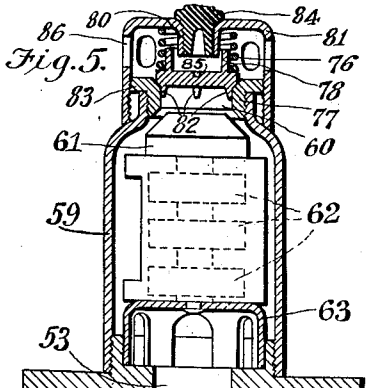
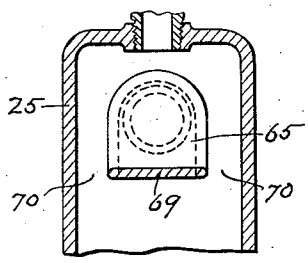


Fig. 2.

Fig. 3.

Fig. 4.



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UNITED STATES PATENT OFFICE.

WILLIAM K. SIMPSON, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO HOFFMAN SPECIALTY COMPANY, OF WATERBURY, CONNECTICUT, A CORPORATION OF ILLINOIS.

VAPOR HEATING SYSTEM.

1,408,478. Specification of Letters Patent. **Patented Mar. 7, 1922.**

Application filed March 31, 1921. Serial No. 457,254.

To all whom it may concern:

Be it known that I, WILLIAM K. SIMPSON, a citizen of the United States, residing at East Orange, in the county of Essex and State of New Jersey, have invented new and useful Improvements in Vapor Heating Systems, of which the following is a specification.

This invention relates chiefly to a vapor-heating system having means adapted and operative to limit the differential pressure between the supply pipe which furnishes the heating agent to the radiators of the system, and the return line which conducts water of condensation back to the heater, to a given predetermined amount, said means being embodied in an equalizing loop, the operation of which is hereinafter described. The invention may, however, relate to a vapor-heating system not including said equalizing loop.

One object of the invention is to provide means for positively separating the air and water of condensation flowing together through the return line, permitting the air to freely escape through a thermostatically controlled venting valve, and causing the condensate to return to the boiler.

Another object is to render more positive than heretofore the action of said equalizing loop.

The invention is embodied in the improvements which I will now proceed to describe and claim.

Of the accompanying drawings forming a part of this specification—

Figure 1 is an elevation showing diagrammatically a vapor-heating system of which the separating means of my invention forms a part, the separator hereinafter described being shown in section.

Figure 2 is an enlarged sectional view, showing the separator, the venting valve as used in an open system, and the equalizing loop.

Figure 3 is a section on line 3—3 of Figure 2.

Figure 4 is a section on line 4—4 of Figure 2.

Figure 5 is a fragmentary sectional view shrowing the venting valve as used in a closed or vacuum system.

Figure 6 is a fragmentary elevation showing certain modifications.

The same reference characters indicate the same parts in all of the figures.

11 represents a heater having the characteristic elements of a steam boiler, from the steam space of which a rising pipe 12 leads. This pipe is connected with a steam main 13, which is of sufficient capacity to supply steam to as many radiators 14, as it is required to supply, each radiator being connected with the main 13 through a connection 15 having a valve 16. The main 13 is preferably slightly pitched downward away from the rising pipe 12. The water of condensation in the radiator, together with any air which may have been carried thereto with the vapor, flows through an outlet valve 20, and return connection 21, to a return line 22, which is preferably connected with the steam main 13 by means including conduit members 23, 23^a, 23^b and 23^c, the member 23^a being a thermostatic trap adapted to prevent the passage of steam from the main 13 to the return line 22. A dirt pocket adapted to catch dirt, sediment and scale is shown at 23^d. The return line 22 is located as high as is conveniently practicable above the level of the water surface in the boiler, indicated at 24, and is substantially horizontal, but is slightly pitched downward toward the boiler. Connections between the return line 22 and the boiler are provided by the casing portion 25, of the separator hereinafter described, the upper portion of which communicates with the return line 22, a pipe 26 leading from the lower portion of the casing 25, and entering the boiler below the water line 24. A by-pass 27 is also provided, extending from the return line 22 to the pipe 26, at a point in the latter, preferably below the water line 24, the purpose of this by-pass being hereinafter stated.

An equalizing loop shown as a whole at

28 has its upper end portion connected at 30 with the upper end portion of the separator casing 25. Said loop is connected at a lower point with a pipe 29 which, as shown by Figure 1, may communicate with the steam main 13. As shown by full lines in Figure 6 the pipe 29 may communicate with a boiler header 29^a connected with the steam space of the boiler. As shown by dotted lines at 29^b in Figure 6, the pipe 29 may communicate directly with said steam space.

The equalizing loop which is set forth and claimed in the application of George D. Hoffman, filed July 9, 1918, Serial No. 244,103, is here shown and described to make clear the operation of the system which includes the improvements described and claimed herein.

The equalizing loop here shown is constructed of a shell, composed of an upper section 31, and a lower section 31^a, and provided with an inlet 32 with which is connected the pipe 29, and with an outlet 33, which communicates with the connection 30. In the upper section 31 is a transverse partition 35, which divides this part into two chambers 36 and 37, the former having a relatively large capacity, and the latter providing a space into which the inlet 32 opens, and with which the interior of the lower section 31^a is in connection.

In the partition 35 are two tapped holes, in one of which is secured the upper end of a pipe 38, called the balancing pipe, and in the other of which is secured a pipe 39, called the equalizing pipe, of which the upper end rises above the partition to a point above the lower edge of the outlet 33.

The balancing pipe 38 extends into the lower end of the loop casing and its upper end is below the surface of an accumulation of water in the loop.

The equalizing loop, as more fully described in the above-mentioned Hoffman application, constitutes a means for maintaining a given pressure difference between the steam main 13 and the return line 22, and between said main or the steam space of the boiler, or the header 29^a hereinafter described, and for equalizing in the return line, pressures generated in the boiler greater than such difference, the construction of the loop being such as to permit flow of steam into the return line when the difference in levels of the columns in the two legs of the equalizing loop becomes more than a given predetermined amount.

I provide a means for positively separating air and water of condensation which flow together in the return line 22, said means having provisions for permitting air to freely escape through a thermostatically controlled venting valve, and for causing the water to return to the boiler, the means of my invention rendering the action of the equalizing loop more positive, in that it supplies a chamber 25^b which has connection with the equalizing loop and with the four elements, by which it is possible to control a vapor-heating system, namely, the steam main, the return line, the boiler, and the venting valve.

The said chamber 25^b is formed by the separator casing 25, said casing being vertically elongated and having an orifice 41 at its lower end, communicating with the pipe 26 leading to the boiler, an orifice 42 at one side of its upper end portion, communicating with the return line section 22^a, and an orifice 43 at the opposite side of its upper end portion, communicating with the section 30, between the separator and the equalizing loop, the orifices 41 and 42 being preferably internally threaded, and the orifice 43 being preferably the bore of a nipple which is externally threaded to engage a union 45.

The head 25^a forming the upper end of the casing 25, has a venting orifice 46, communicating with a thermostatically controlled venting valve, which may be of any suitable construction. The valve shown by Figure 2, includes a casing 47, having a lower head 50, provided with a threaded neck 51, screwed into the orifice 46, and an upper head 52, in which is a port 53, forming a seat, cooperating with a valve disc 54. This valve disc is connected to a float 55, which is formed as a bell, open at its lower end, and guided by a valve rod 57, mounted on a spider 58, which is suitably secured to the lower head. When water enters the casing 47, the float 55 rises and closes the valve disc 54, so that water cannot escape through the port 53. When the water recedes the valve disc 54 recedes from its seat. On the top of the head 52 is a casing 59, having a port 60, controlled by a valve disc 61, operated by a thermostatic motor, consisting of a series of expansible chambers 62, connected with one another and in intercommunication, the chamber at one end of the series being secured to the valve disc 61, and that at the other end being mounted upon a perforated frame or spider 63, which is securely mounted in any desired way. This thermostat is so designed as to be expanded and to close the valve disc 61, when raised to a temperature approximating that of live steam, and to be opened when its temperature is lowered to that of the condensate of the steam.

The separator includes a deflecting and guiding member, which may be cast integral with the casing 25, and preferably includes two cupped portions or hoods 65 and 66, connected by a neck or web 69, a plan view of which is shown by Figure 3. The concave under sides of the hoods form guides 67 and 68, communicating respectively with

the orifice 42 receiving the return line, and with the orifice 43 with which the loop connection 30 communicates. The neck 69 is separated from portions of the internal surface of the casing 25, to form main air ports 70, at opposite sides of the base or lower portion of the deflecting member. The hood 66 is provided in its upper portion with an auxiliary air port 71, located above the main ports 70.

Operation.

During the venting period air and water of condensation flow through the return line 22 in the direction indicated by arrow x and are initially deflected downward by the hood 65, the air immediately separates in the chamber 25^b from the condensate and rises through the air ports 70. The relatively heavy condensate gravitates downwardly and passes through the pipe 26 into the boiler. In large systems, or those which have excessive condensation, such as would result from the use of indirect stacks or blast coils, a portion of the condensate may pass to the boiler through the by-pass 27 without entering the separator, the by-pass being connected with the pipe line 26 at a point below the common water level in the boiler and in the line 26.

If the differential pressure maintained by the equalizing loop, between the steam main 13 and the return line 22, and between said main, or the boiler steam space, or the header 29^a, were to increase beyond the predetermined amount, the increased pressure acting on the water in the pipe line 26, would permit the water to instantly rise and back up in the return line 22, and leave the boiler to such an extent, as to cause liability of burned or cracked boiler sections, and danger of an explosion. The equalizing loop and the air separator cooperate as follows, to prevent this condition and liability:

As soon as there is an increase in differential pressure between the steam main 13 and the return line 22, steam passes through the equalizing loop into the air separator, through the port or passage 68 formed by the hood portion 66 of the deflecting and guiding member. The incoming steam fills the separator casing 25, and passing through the ports 70, reaches the thermostatic member or motor in the venting valve, instantly closing the valve disc 61 on its seat and cutting off the system from connection with the atmosphere. By this action the pressure in the return line 22 is instantly increased, and the predetermined differential between the steam main and the return line is restored, so that water is prevented from backing up in the return line and from leaving the boiler. The above described action is instantaneous.

As soon as the differential pressure is restored, the flow of steam through the equalizing loop is automatically cut off by restoration of the water seal on equalizing pipe 39, until there is need for a repetition of the action, in order to restore differential pressure.

To render the function of the air separator positive, and cause the described action to take place under abnormal conditions, the auxiliary air port 71 is provided, this port permitting steam to reach the thermostatic member of the venting valve, if conditions are such that water has risen in the separator casing 25, to a point above the bottom of the deflecting member, as indicated by the line y, y (Figure 2), and has, therefore, closed the ports 70 and prevented the passage of steam therethrough.

When the heating system includes a venting valve such as that shown by Figure 2, air is permitted to return to the system through the vent port 53 when the valve disc 54 is in open position, there being no provision for preventing the return of air through said vent port, so that an open vapor-heating system is provided. The invention may be embodied in a heating system in which provision is made in the thermostatically controlled venting valve for preventing the return of air through the vent port 53, so that a vapor vacuum or closed heating system is provided.

To accomplish this the venting valve may be provided, as shown by Figure 5, with a check valve disc 75, normally held by its own weight or by a spring 76 in position to prevent the return or inflow of air through the venting valve, preferably by bearing on a seat at the upper edge of a ring 77, the bore of which forms the port 60, the lower edge of said ring forming a seat for the valve disc 61. The check valve disc 75 may be guided and caused to seat properly by a tubular guide member 78, fixed to the disc, a guide member or spud 80, fixed to a cap 81, and entering the member 78, and wing guide members 82 in sliding contact with the wall of the vent port 60. The ring 77 is externally threaded to engage an internal thread at the upper end of the casing 59, and is provided with an externally threaded annular flange 83, engaging an internal thread in the cap 81.

The guide member 80 is preferably tubular, and internally threaded to engage a threaded plug or closure 84, the removal of which permits the insertion of a screwdriver through the guide member 80, to engage a slot 85 in the check valve disk for the purpose of rotating the latter and grinding its face and that of its seat, to remove matter caused by corrosion, which might prevent an air-tight fit of the disk on the

seat. The cap 81 is provided with openings 86 for the escape of air. To prevent the entrance of dust to the check valve disk through said openings, the latter may be guarded by fine wire gauze, or by porous material, such as loose hair felt suitably secured to or confined in the cap.

The operation of the valve shown by Figure 5 is the same as that of the valve shown by Figure 2, with the exception that a slight pressure is necessary to raise the check valve disc 75 from its seat. Upon the release of pressure the disc 75 is seated and closes the port 60 against intake of air. After this and while the condensation in the radiators continues, a vacuum forms which causes the generation of steam or vapor under conditions below atmospheric pressure, that is to say, vapor is generated at temperatures below 212° F. For relatively low pressure the spring 76 is unnecessary, but when it is desired to operate the valve under pressures above the range of vapor vacuum heating, a light spring load is advisable.

It is to be understood that the words "vapor heating system" as used herein and in the appended claims, refer to a system either with or without means for preventing return of air through the venting valve, that is to say, to either an open or a closed system.

It will now be seen that my invention is distinguished from the prior art exemplified by the above-mentioned Hoffman application, by a separator communicating both with the return line and with the equalizing loop and constructed to operate as above stated, and by a thermostatically controlled venting valve, communicating directly with the separator.

The separator and the venting valve collectively constitute a vapor-heating system element which may be so modified that the only functions of the said element are to positively separate the air and condensate flowing through the return line, and to permit the escape of air, and prevent the escape of water through the venting valve, the latter being closed only by an accumulation of water in the separator, there being no means for admitting steam to the separator casing.

The underlying principle of the separator is that air and condensate flowing together in the return main 22 are given an abrupt change in direction and deflected into an enlarged chamber 25^b, wherein, because of their different gravities, positive gravitational separation of the two elements is obtained. The relatively heavy spray or entrained moisture gravitates to the condensate outlet provided by the pipe 26, the air passes upward through the ports 70 to the outlet provided by the venting orifice 46 and neck 51 without carrying with it enough spray or entrained moisture to cause an accumulation of the same sufficient to cause the float 55 to operate, as it would if water surged into the valve. The action of the venting valve is thus made more positive in that it can take care of a condition which it could not otherwise handle without the aid of the separator.

I claim:

1. The combination in a vapor-heating system, of a boiler, a radiator, steam and return lines between the boiler and the radiator, a loop between said lines having means to maintain a given pressure difference between them while permitting passage of steam from the steam line to the return line when the excess of the boiler pressure over the return line pressure exceeds the given difference, a separator communicating with the loop, the return line, and the boiler, and adapted to receive steam from the loop, said separator having means for separating the air and water of condensation flowing through the return line and an air escape vent above said means, and a thermostatic valve controlling said vent, said valve comprising means to permit escape of air, and to prevent escape of steam from the separator.

2. A vapor-heating system embodying the combination specified by claim 1, and including also a by-pass between the return line and the boiler, outside the separator, for the return of a portion of the condensate to the boiler.

3. The combination in a vapor-heating system of a boiler, a radiator, steam and return lines between the boiler and the radiator, a separator between, and communicating with, the return line and the boiler, and having means for separating the air and water of condensation flowing through the return line, and an escape vent above said means, and a valve controlling said vent, said valve comprising means to permit escape of air, and prevent escape of water from the separator.

4. A vapor-heating system embodying the combination specified by claim 3, and including also a by-pass between the return line and the boiler outside the separator for the return of a portion of the condensate to the boiler.

In testimony whereof I have affixed my signature.

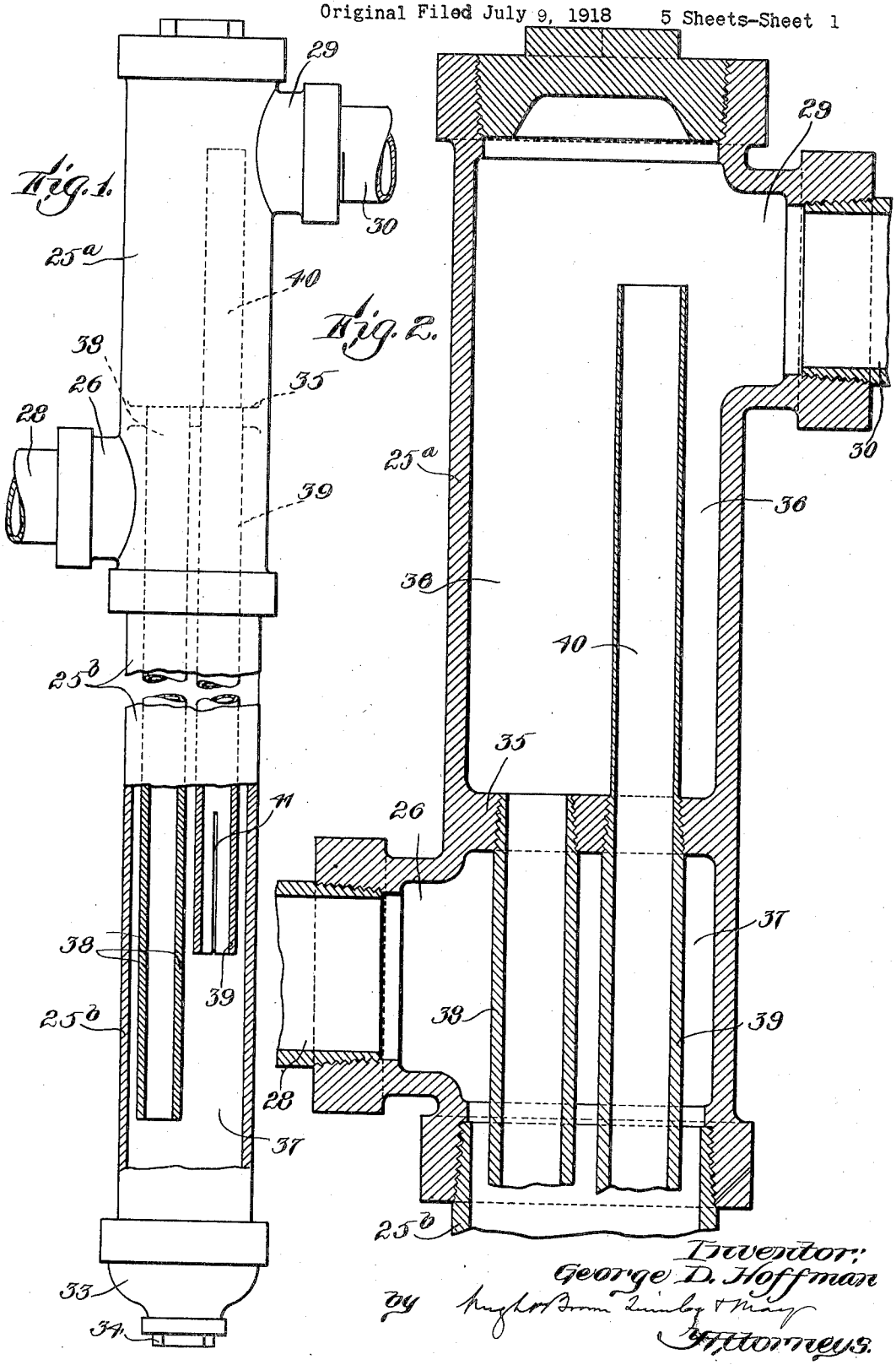
WILLIAM K. SIMPSON.

Feb. 9, 1926. 1,572,482

G. D. HOFFMAN

VAPOR HEATING SYSTEM WITH DIFFERENTIAL LOOPS

Original Filed July 9, 1918 5 Sheets-Sheet 1



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Feb. 9, 1926. 1,572,482

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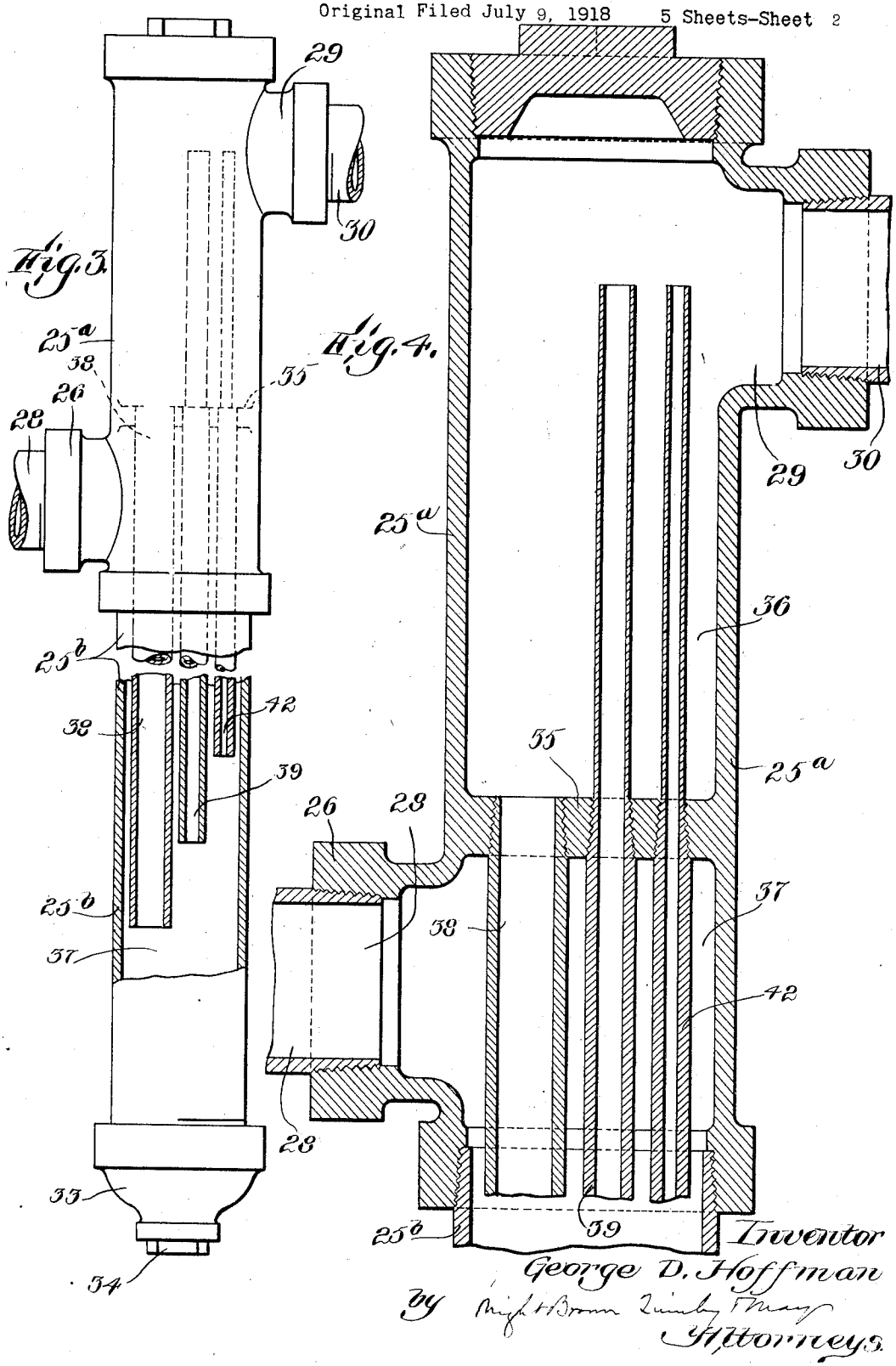
VAPOR HEATING SYSTEM WITH DIFFERENTIAL LOOPS

Original Filed July 9, 1918 5 Sheets-Sheet 2



Feb. 9, 1926. 1,572,482

G. D. HOFFMAN

VAPOR HEATING SYSTEM WITH DIFFERENTIAL LOOPS

Original Filed July 9, 1918 5 Sheets-Sheet 3

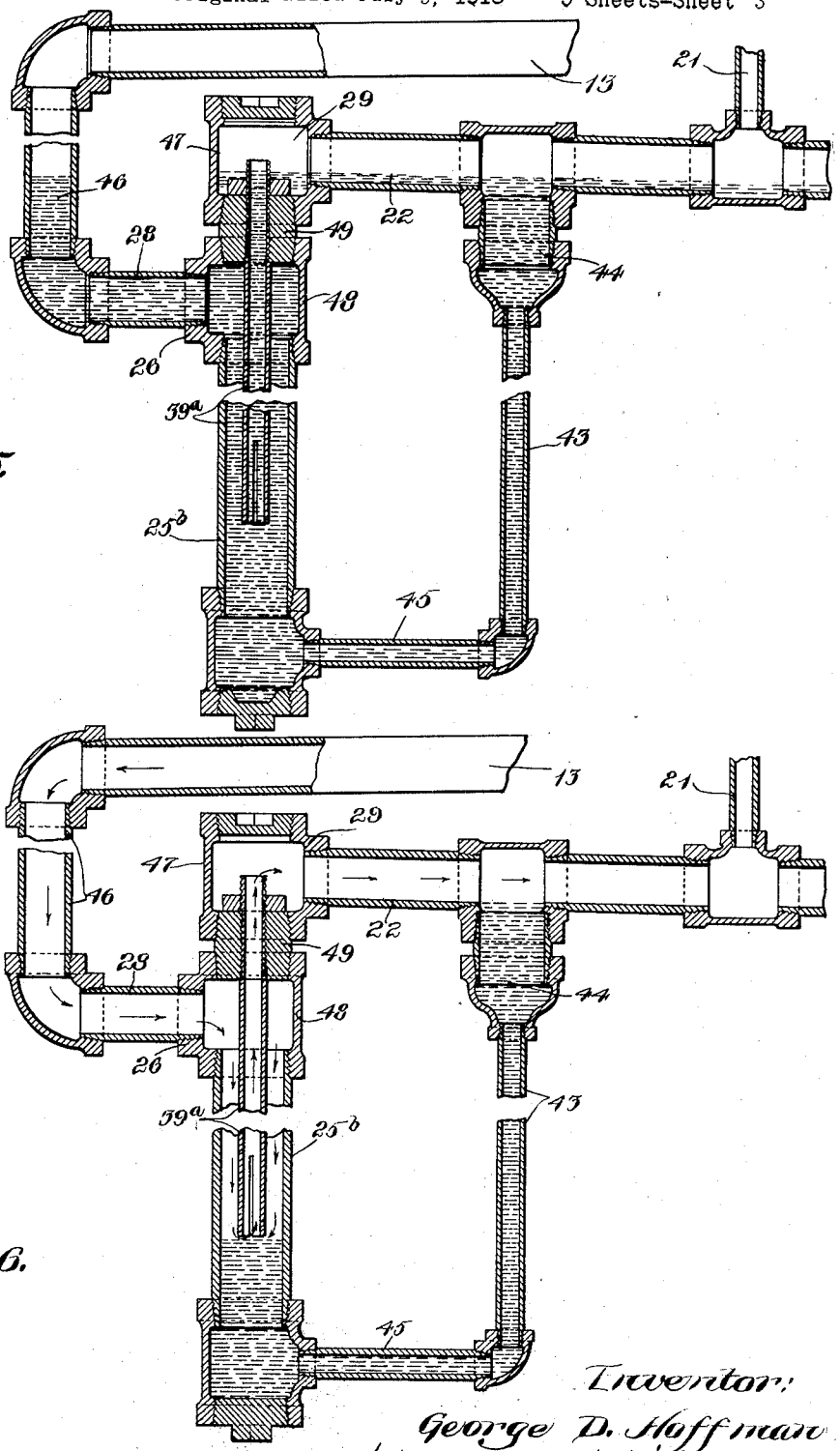


Fig. 5.

Fig. 6.

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VAPOR HEATING SYSTEM WITH DIFFERENTIAL LOOPS

Original Filed July 9, 1918 5 Sheets-Sheet 4

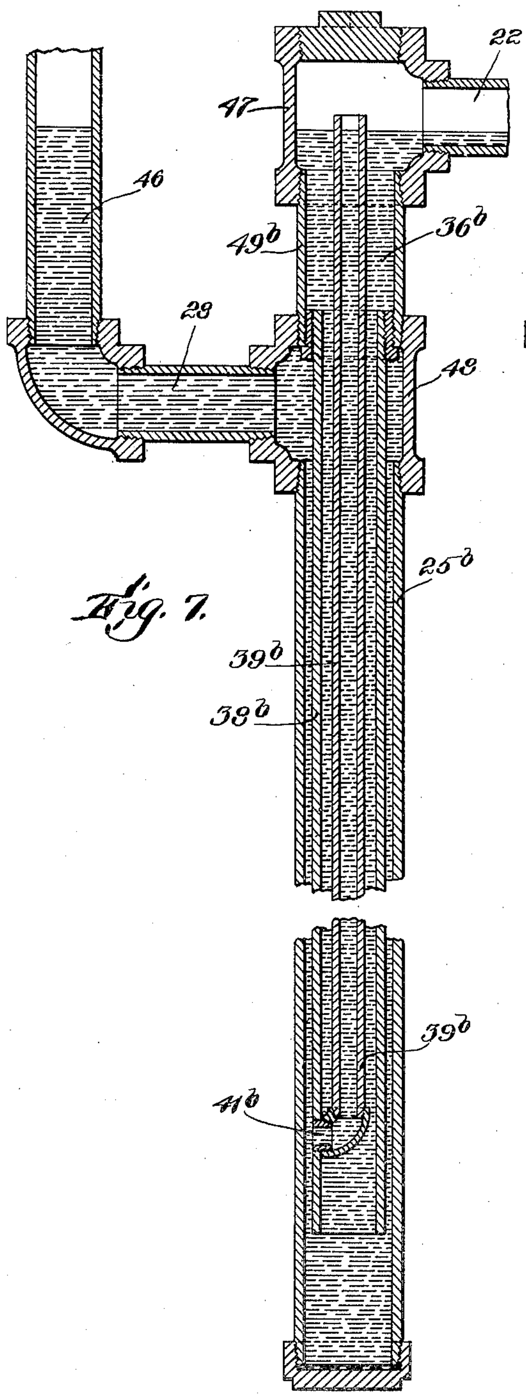

Fig. 7.

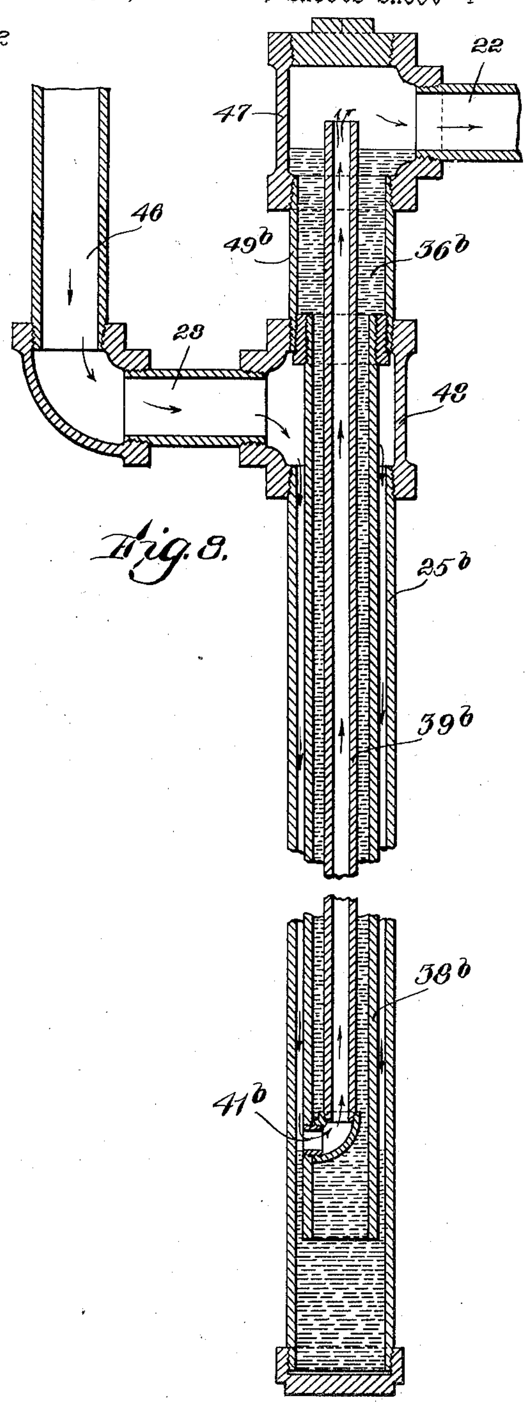

Fig. 8.

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VAPOR HEATING SYSTEM WITH DIFFERENTIAL LOOPS

Original Filed July 9, 1918 5 Sheets-Sheet 5

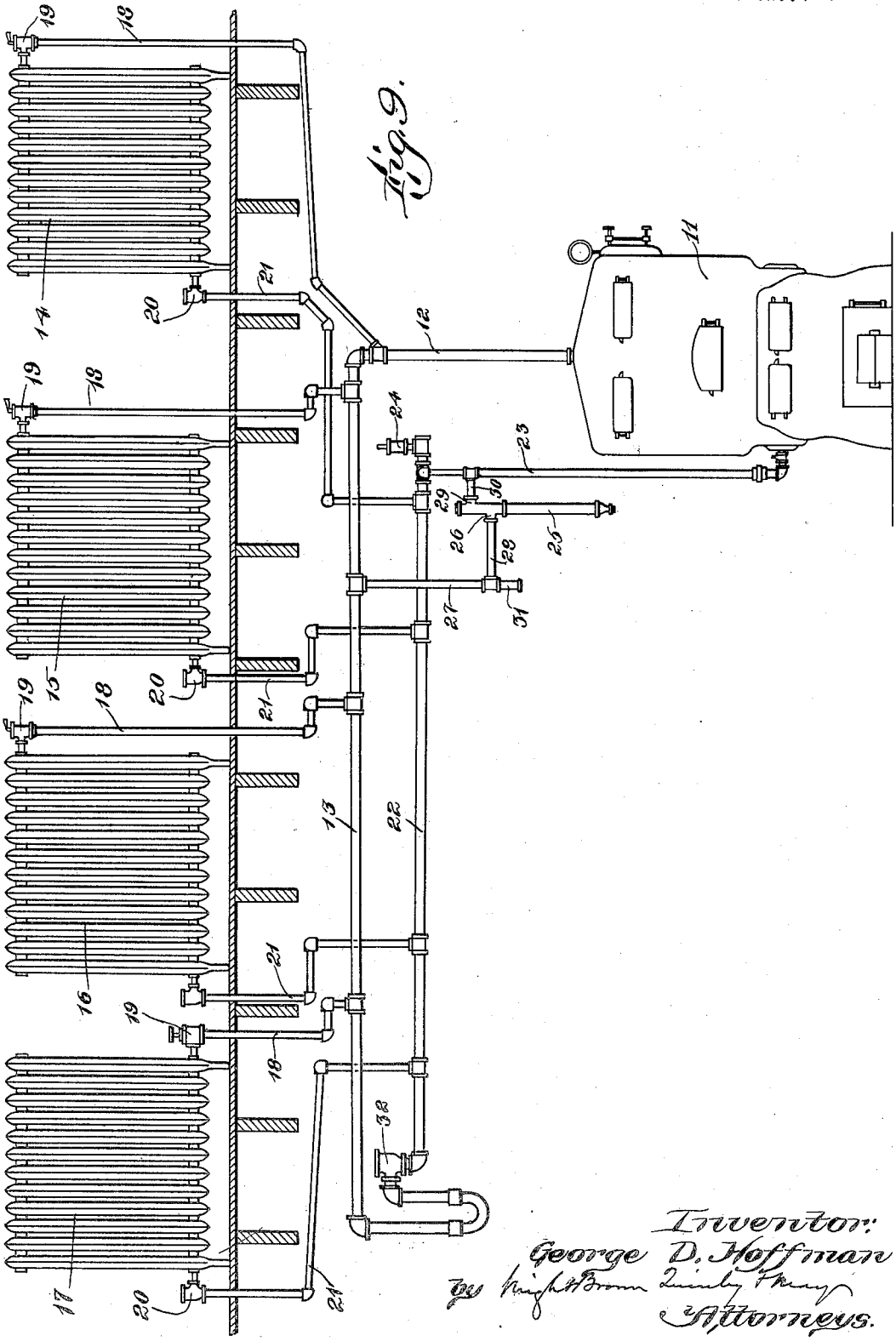

Fig. 9.

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Patented Feb. 9, 1926. 1,572,482

UNITED STATES PATENT OFFICE.

GEORGE D. HOFFMAN, OF PASADENA, CALIFORNIA, ASSIGNOR TO HOFFMAN SPECIALTY COMPANY, OF WATERBURY, CONNECTICUT, A CORPORATION OF ILLINOIS.

VAPOR HEATING SYSTEM WITH DIFFERENTIAL LOOPS.

Application filed July 9, 1918, Serial No. 244,103. Renewed September 24, 1925.

To all whom it may concern:

Be it known that I, GEORGE D. HOFFMAN, a citizen of the United States, residing at Pasadena, in the county of Los Angeles and State of California, have invented new and useful Improvements in Vapor Heating Systems with Differential Loops, of which the following is a specification.

This invention relates to low pressure steam heating systems, known in the trade as vapor heating systems, the principal distinguishing characteristic of which is that the working steam pressure is very low, being measured in ounces instead of pounds per square inch. Such systems include, in addition to the boiler and radiators, a steam line for delivering steam to the radiators, and a return line for conducting water of condensation back to the boiler and for conducting to a point of discharge into the atmosphere air forced by steam from the radiator. In order that it may perform these functions, a part of the return line, called the "dry return line" is located above the height to which the normal boiler pressure will raise water, in a nearly horizontal arrangement, but with a sufficient pitch downward toward the boiler; and the terminal part of the return line is conducted to the boiler below the water level therein. The dry return line is normally open to the atmosphere through an automatic thermostatically controlled vent, preferably and usually located near the boiler. When steam pressure is generated in the boiler, water rises in the terminal part of the return line to a height above the boiler water level sufficient to balance such pressure; such rise of water being approximately one and three-fourths inches for each ounce of steam pressure. Usually the dry return line includes a relatively great length of nearly horizontal piping with a vertical terminal section; and it is located as high as feasible above the water level in the boiler in order that under ordinary pressure the water will not be forced back into the line in sufficient quantities to uncover those surfaces of the boiler which are exposed to the direct heat of the fire, since, if these surfaces should be uncovered, the boiler might be ruined by warping, cracking, burning, etc.

It sometimes happens in the operation of such systems that the boiler pressure is permitted, accidentally or otherwise, to mount above the normal working pressure. For example, a system may be designed to operate under a normal working pressure of eight ounces and a maximum unbalanced pressure of ten ounces per square inch. Then, if the dry return line is placed more than seventeen and one-half inches above the boiler water level, it will remain clear of water so long as the boiler pressure does not exceed the prescribed maximum. But a boiler pressure of several pounds per square inch is easily obtainable by making too hot a fire, and it is generally impossible to place the lowest horizontal runs of the dry return line at the height above the boiler water level to which a pressure of even a few pounds will raise a water column.

The purpose of my invention is to make it impossible for water to back up from the boiler into the return line or radiators of a vapor heating system, though the boiler pressure be raised to no matter how high a degree above the normal working pressure, and though the horizontal dry return line be no higher above the boiler water level than the height of a water column which balances a predetermined maximum working pressure; and at the same time to accomplish the following additional results:—

(1) To enable a variable operative pressure difference between the steam and return lines of the system to cause circulation of steam when the boiler pressure is lower than a certain predetermined value.

(2) To maintain a substantially constant pressure differential between the steam and return lines when the boiler pressure exceeds a predetermined amount, and thereby cause circulation of steam in a manner similar to that occurring when atmospheric pressure is maintained in the return line and a pressure is generated in the steam line equal to such pressure differential.

(3) To retain the steam in the system and prevent loss thereof to the atmosphere no matter how high the pressure may mount.

(4) To retain water in the boiler and prevent it blowing out to the atmosphere when the boiler steam pressure is excessive;

(5) To permit release of air from the

return line, even during the continuation of high pressure conditions;

(6) To enable a radiator which was previously shut off and has been turned on during the continuation of these high pressure conditions, to become heated quickly and continue functioning in its normal way; and

(7) To restore the previous conditions and open the return line to the asmosphere as soon as the boiler pressure has diminished to the prescribed maximum differential.

I have accomplished these objects and results by combining with a vapor heating system and a thermostatically controlled vent therein, a device which I call a "differential loop" in the manner which I will now describe in detail.

The invention consists in this combination and equivalents thereof as well as in subordinate characteristics, all as hereinafter described and pointed out in the claims.

In the drawings forming part of this specification—

Figure 1 is an elevation, partly broken away, of one form of differential loop embodying my invention which I have applied to the heating system for the purposes above mentioned.

Figure 2 is a longitudinal section of the upper part of said loop on an enlarged scale.

Figures 3 and 4 are views similar to Figures 1 and 2, respectively, of another form of the loop.

Figures 5 and 6 are sectional views showing a third form and illustrating further its conditions and mode of operation under normal pressure and excess pressure, respectively.

Figures 7 and 8 are views similar to Figures 5 and 6 of a fourth form of the invention.

Figure 9 is a diagram illustrating the invention applied in a two pipe heating system.

Like reference characters designate like parts in the various figures.

Referring first to Figure 9 for explanation of the entire system, 11 represents a heater which may be considered as having the characteristic elements of a steam boiler, and from the steam space of which a rising pipe 12 leads. This pipe is connected to the steam line or main 13, which is a pipe of sufficient capacity to supply steam to all the radiators of the system, and is substantially horizontal, but preferably slightly pitched downward away from the boiler. 14, 15, 16 and 17 represent radiators which are supplied by steam connections 18 leading from the steam main 13 and controlled by valves 19. The water condensed in the radiators, together with any air which may have accumulated therein from any cause, flows through outlet valves 20 and the several return connections 21 to the dry return line 22. This return line is located above the level of the water surface in the boiler a distance sufficiently greater than the height to which the maximum unbalanced pressure will force a column of water; and is substantially horizontal but is slightly pitched downward toward the boiler to cause a sufficiently rapid return flow of water; and it is joined to the boiler by a rising or substantially upright or vertical pipe 23, the latter being the vertical end of the dry return line leading into the lower part of the boiler below the water level therein. 24 represents a vent valve in the return line which is normally open to the atmosphere but is adapted to be closed by a float or by a thermostatic motor when the return line is either flooded with water or is filled with steam.

The differential loop is shown at 25 in Figure 9. It is provided with an inlet 26 which is connected with the boiler so as to be affected by the pressure therein, by an upright pipe 27 leading from the steam main, and a lateral connection 28, or by any other suitable connection; and is further provided with an outlet 29 connected through a pipe 30 with the upright pipe 23 of the return line. Thus the outlet of the loop is in close connection with the thermostatic valve 24 controlling the vent of the return line. There is an extension 31 of the upright pipe 27 below the connection 28, which is provided for entrapping sediment.

In the arrangement shown the loop is thus connected to the steam and return lines at a point near the boiler, and in some cases this is the preferable location; but under other conditions it may, and sometimes should, be located at the remote ends of the steam and return lines. Also, in the arrangement shown, the remote end of the steam line is connected with the return line so as to permit return of the water condensed in the steam line, steam being prevented from flowing directly into the return line by a thermostatic valve 32 which may be of the same type as the radiator return line valves 20. However, instead of connecting the lines as last described, it is within my contemplation to provide a separate return connection from the remote end of the steam line to the pipe 27. Preferably the connections between the loop and the boiler should be of such length and so arranged as to maintain an adequate volume of water in the loop by delivering condensed steam thereto. The present drawings show an arrangement suitable for this purpose.

The form of differential loop shown in Figures 1 and 2 comprises a shell or casing made of an upper part or casting 25^a into which the inlet and outlet open, and a lower part 25^b joined by a screw-thread to the

upper part and closed at its bottom by a reducer 33 in which there is a plug 34 which is readily removable for the purpose of cleaning. In the part 25ª is a transverse partition 35 which divides the interior of the shell into two chambers 36 and 37, the former having capacity for storing a large volume of water, and the latter providing a space into which the inlet opens.

In the partition or diaphragm 35 are two tapped holes in one of which is screwed the upper end of a pipe 38, which I call the balancing pipe, and in the other of which is screwed a pipe 39 which I call the equalizing pipe. The latter rises above the partition to such height above the lower edge of the outlet that its orifice is above the surface of the water which collects in the loop. That part of the equalizing pipe which rises above the partition is designated 40 and is called, for the purpose of this specification, the equalizing pipe extension. This extension is not a prime essential of the invention, but is useful as a means for giving free course to the flow of steam through the loop. The terms thus applied to the pipes and other elements of the differential loop are descriptive and have no limiting significance, but include all elements or devices having the essential characteristics, as to function and result, of the parts here shown and described. In the lower end of the equalizing pipe is an upwardly extending slot 41 which forms a restricted inlet orifice. This slot may be cut through either or both walls of the pipe and it is preferably so designed that it may be cut by a metal cutting saw. Any other form of restricted orifice having essentially the same mode of action, presently described, by whatever means made is, however, within the scope of the protection which I claim for this part of the device.

The balancing pipe extends into the lower part of the loop casing, and its lower orifice in any case must be well below the upper end of the slot 41. The upper end of the balancing pipe preferably terminates at or in the partition 35 and in any event is below the outlet pipe 30 of the loop.

I will explain the operation of the invention as thus far described before describing the other modifications illustrated in my drawings. Water of condensation accumulates till it fills the loop casing, and the balancing pipe and equalizing pipe up to the outlet connection 30. The chamber 37 of the casing forms one leg, and the balancing pipe, with the connected upper chamber 36, forms the second leg, of an upright U-tube or loop between the steam main and the return line, which is sealed by water, and in which the greatest possible height of the water column in one leg above the water level in the other leg cannot exceed the distance from the bottom of outlet pipe 30 to the bottom of the balancing pipe. Actually, however, the equalizing pipe limits the height of such column to the distance from said outlet pipe to a point between the upper end of slot 41 and the bottom of the balancing pipe, by permitting steam to flow whenever the water level in the loop casing has been depressed far enough to uncover the upper end of the slot or orifice 41. The actual distance to which such water level is so depressed may vary more or less according to the degree of the boiler pressure and the suddenness with which an unbalanced steam pressure is applied to the loop. In case, for example, the pressure difference between the steam and return lines of the system is limited to ten ounces, the vertical height between the bottom of the outlet pipe 30 and the top of the slot 41 in the loop adapted to that condition is equal to about 17½ inches, the approximate height of the water column which, at the boiling temperature, balances a pressure of ten ounces. Evidently, however, this vertical distance may be proportionately increased or diminished, according as the maximum allowable pressure difference is greater or less than ten ounces.

Assuming that the values in the system are those above given and that the boiler pressure is ten ounces or less, the application of such pressure in the boiler chamber 37 of the loop maintains a column of water in the balancing pipe 38 and chamber 36 equal in height, above the water level in the chamber 37, to the height to which water is raised in the vertical end 23 of the return line, by the same pressure, above the boiler water level. Now, if the boiler pressure rises above ten ounces, the surface of the water leg in the casing is depressed far enough to uncover the orifice of the equalizing pipe, permitting steam to flow through that pipe and thence through the outlet connection 30 into the return line and to the vent valve 24 located in this line. This valve, being thermostatic, and being in a position where the steam reaches it immediately after passing through the loop, is closed by the heat of the steam; whereby escape of steam into the atmosphere is prevented and a back pressure is created in the return line, preventing water from being forced out of the boiler into the return line. Steam flows into the return line in greater or less volume, and such back pressure is built up at a rate proportional to the amount and rapidity of the rise of boiler pressure, through the water level in the chamber 37 being depressed more or less in the same proportion, whereby the entrance orifice (slot 41 and end opening) of the equalizing pipe is uncovered to a larger or smaller extent. When this back pressure has been

so raised to within ten ounces of the boiler pressure (or, in general terms, to an amount equal to the difference between the boiler pressure and the pressure equivalent of the water column in the loop) water from the chamber 36 and balancing pipe 38 flows back into the chamber 37, sealing the equalizing pipe and preventing further rise of pressure in the return line.

Thus the loop, while permitting steam under abnormally high pressure to pass from the boiler into the return line, always maintains a differential between the boiler and return line pressures, due to the water in the loop which must be raised as a column of a certain height before steam can pass, and which stops flow of steam when the existing differential is within the prescribed maximum. The equalizing pipe 39 is, in effect, a by-pass between that leg (chamber 37) of the loop which is in steam connection with the boiler and the return line connection of the loop, leading from such a low point in the leg specified that a difference between the water levels in the two legs equal to the head equivalent to the prescribed differential must be obtained before steam can pass through it. When the boiler pressure exceeds the prescribed differential, this by-pass permits steam to blow over from the boiler to the return line, without emptying the loop of water, in whatever amount is necessary to equalize such pressure excess. Equalization in the return line of the excess boiler pressure then takes place through the compression of air entrapped in the return line by the flow of steam into that line after closing of the thermostatic vent. The pressure in the return line is exerted on the head of the water column in the leg formed by the chamber 36 and pipe 38, and tends, together with the weight of that column, to raise the water level in the leg formed by chamber 37 and thereby seal the by-pass; while tendency of excess boiler pressure is always to depress the water in leg 37 and uncover the by-pass.

I have found that, in the operation of the device, these tendencies quickly reach a condition of approximate equilibrium in which just enough steam is allowed to pass through the equalizing pipe to equal the excess pressure in the boiler and so prevent water leaving the boiler and flooding the return line, but not to reduce the pressure differential, which is always maintained at the given value of ten ounces (or whatever it may be for any particular case). An increase in the boiler pressure causes more steam to flow through the equalizing pipe in exactly the measure necessary to balance this increase, while decrease of boiler pressure allows the entire flow of steam through the equalizing pipe to be cut off. Although the water level in the chamber may surge and fluctuate while the boiler pressure is above ten ounces, alternately opening and closing the equalizing pipe, such fluctuations occur so rapidly that the pressure differential between the steam and return lines remains substantially constant.

Thus the system is enabled automatically and instantly to adapt itself to all pressure conditions and return to normal operating conditions after having been under an abnormal pressure, and to do so without noise. Transfer of water from the boiler to the return line is prevented without loss of water or steam into the atmosphere, without occurrence of water hammer, without blowing the water seal from the loop, and without necessity for reducing the pressure in the system to that of the atmosphere preliminary to restoring the normal working conditions; while always there is maintained the pressure difference between the boiler and the return line necessary to enable steam flowing from the boiler to force itself into the radiators and to expel from the latter the water of condensation and any air which may be trapped in them. When the boiler pressure subsides to, or below, the prescribed differential, after having risen above it, blowing of steam over into the return line ceases, the thermostatic vent in this line opens, and the system continues to function without interruption in the normal way.

I have found that the restricted orifice to the equalizing pipe provided by the notch 41, which makes a graduated opening according as it is uncovered to a greater or less extent by subsidence of the water in the outer leg, and the storage chamber of relatively large capacity provided at 36 in the upper end of the loop casing, are elements which appear in practice to be, if not absolutely essential, at least highly important in securing the results described. The location of the equalizing pipe at the side of the loop next to the outlet also has an important effect in a loop made substantially as that here shown, where the outlet opens from the side of the casing, such effect being to prevent, in sufficiently large measure, loss of water entrained by the steam which flows through the equalizing pipe when the loop acts. At such times a substantial amount of water is entrained with the flowing steam, and if the water were allowed to escape through the outlet with the steam, the loop would be drained and its power to maintain the desired differential destroyed by loss of the water head which is relied on to maintain the differential. But with the equalizing pipe arranged at the side of the casing next to the outlet, the water which issues from this pipe strikes the top wall or upper head of the casing and is baffled and deflected from the outlet, whereby the

water is separated from the steam and most of it retained in the loop while the steam flows through the outlet. In effect the adjacent head serves as a means for baffling and separating entrained water from the flowing steam. Whatever water is not thus separated and escapes with the steam is more than made up by the condensation in the connection from the steam line to the loop.

Figures 3 and 4 illustrate the same principle applied in a slightly different form, in which there are two equalizing pipes, namely, 39 and 42, each having its extension rising through the storage chamber 36. The pipe 42, being of restricted diameter and extending to not quite such a low point as the pipe 39, permits a restricted flow of steam before the orifice to the pipe 39 is opened at all, and thus serves the same purpose as a restricted orifice in a single equalizing pipe arranged to be uncovered before a large orifice, or an enlargment of a single orifice, is uncovered.

Figure 5 shows a modification in which only the equalizing pipe 39^a is contained within the casing of the loop; the second leg of the loop, which corresponds to the balancing pipe, which I have previously called the inner leg, being formed by an external pipe 43 and a storage chamber 44 which are connected to one another and to the return line 22, and of which the lower end of the pipe 43 is connected by a pipe 45 with a fitting at the bottom of the loop casing. This figure also shows an arrangement in which the inlet of the loop is joined directly to the extreme end of the steam main 13 through a connection 46, and the outlet is connected directly to the extreme end of the return line, remote from the boiler. The top part of the loop casing is made of two T's 47 and 48 which are connected by a bushing 49 in which the equalizing pipe is secured. Figure 6 differs from Figure 5 only in showing the condition when the boiler pressure exceeds the normal amount, steam then flowing through the equalizing pipe, whereas Figure 5 shows the condition when the pressure is at or below normal, the equalizing pipe then containing water.

Figures 7 and 8 show an arrangement in which the balancing pipe 38^b or inner leg is within the casing or outer leg of the loop, and the equalizing pipe 39^b is within the balancing pipe. The inlet orifice of the equalizing pipe communicates with the outer leg of the loop through the side of the balancing pipe 38^b and is shown at 41^b. Figure 7 shows this loop full of water, and Figure 8 shows the condition after the pressure has become great enough to cause flow of steam through the equalizing pipe. All of these various modifications evidently contain the essential principle of the invention hereinbefore pointed out and operate according to the same general law.

By virtue of the thermostatic vent valve 24, escape of steam from the system is prevented when steam blows over through the loop from the steam line, no matter how high the boiler pressure may rise. Thus loss of water from the boiler, either by way of backing up into the return line or into the atmosphere, or by way of escape of steam into the atmosphere is prevented. At the same time the system is maintained in operative condition with a sufficient unbalanced pressure in the steam line to fill a previously closed radiator with steam, when such radiator is opened, and any air which such radiator may have contained is able to escape to the atmosphere.

When, under high pressure conditions, a previously closed radiator is opened, the excess pressure in the steam main, maintained by the water column in the loop, expels any air that may be in the radiator into the return line and fills the radiator with steam. The steam line pressure then transmitted through the open radiator into the return line imposes a back pressure on the loop, causing the loop to be sealed and cutting off, for the time being, live steam from the thermostatic vent valve. Then the small quantity of steam in the return line condenses, and as this takes place the air expelled from the radiator advances to the vent valve. Being cooler than steam, the air, on reaching the vent valve, causes it to open by contraction of its thermostat, and so escapes to the atmosphere. With escape of the entrapped air, however, the return line pressure is lowered to an amount very slightly lower than the difference between the boiler pressure and the predetermined differential, and then live steam again passes the loop and at once closes the vent valve, preventing any further loss of pressure, and at the same time restoring and maintaining the predetermined differential. Thus, whether the boiler pressure is above or below the predetermined amount, free escape of air is permitted and the system can not become air-bound, while at the same time loss of steam is prevented.

It will be noted that the thermostatic vent valve is located very close to the outlet of the loop. This is an important factor in the operation of the system, for it causes the valve to be almost instantly closed when the loop operates, whereby only the minimum amount of steam is required to pass the loop in order to compress the air, then confined in the return line by closing of this valve, to the pressure necessary to prevent backing of water from the boiler; and it limits to the minimum the quantity of steam in the return line which must be condensed, in order to release air to the atmosphere when

a radiator is turned on, or in order to cause opening of the vent valve when the system returns to its normal low pressure condition after subsidence of abnormally high pressure.

It is to be understood, of course, that the particular constructions shown, and the terms applied to the parts and elements thereof, are not intended to limit the scope of the protection hereinafter claimed to those specific constructions. Generically all the forms of differential loop hereinbefore described and all other devices equivalent thereto in purpose, structure, function or result, within the scope of protection hereinafter claimed, are blow over devices adapted to permit transfer or blowing over of steam from the steam line to the return line when the boiler pressure exceeds the prescribed differential, and containing sealing or closing means adapted to resist such steam flow with a continuous yielding force of limited maximum value. The sealing means here disclosed is a column of water, and the force with which it opposes the steam pressure and tends to seal the blow over passageway is the force of gravity, which is limited to the height of the maximum column of water which can exist in the loop, and acts not only before blowing over of steam begins, but also while steam is flowing and without interruption after the flow ceases.

The combination with a heating system as, and with the effect described, of any device which has these essentials is intended to be protected by my claims, whatever may be the specific construction of the device and the specific terms which may most aptly describe the parts thereof.

All systems and combinations substantially equivalent to that here described and pointed out in the following claims are within the scope of my invention and the protection which I claim without limitation by restricted definitions which may be applied to the terms used. Thus, for instance, the term "vapor heating system" is intended to include any low pressure steam heating system of the open or "vapor" type or the closed or so-called "vapor vacuum" type, wherein a loop may be used in the manner and to the effect set forth. The illustration and description of the mode of connection between the steam line and the loop are not intended to indicate any limitation as to the point at which such connection may be made with the pressure side of the system, for the pressure receiving side of the loop may be connected with equally good effect to any part of the steam connections leading from the boiler or even directly to the steam space of the boiler itself.

Having now described a specific form of my invention and explained the principles thereof, but without attempting to describe all the forms in which it may be made or all the possible modes of its use, I declare that what I claim and desire to secure by Letters Patent is:

1. A heating system comprising a boiler, a heating element, steam and return lines between the boiler and heating element, a blow over device having an inlet connected to the boiler and an outlet connected to the return line, and containing a sealing medium adapted to oppose continuous yielding resistance of limited maximum force to the flow of steam from said inlet to said outlet, and a thermostatically controlled vent valve in communication with the return line and with the outlet side of said device, said thermostatically controlled valve being located in close proximity to said outlet.

2. The combination in a vapor heating system of a boiler, a radiator, steam and return lines between the boiler and radiator, a blow over device connected between the boiler and the return line having means to maintain a given pressure difference between them while still permitting passage of steam from the steam line to the return line when the boiler pressure exceeds the given difference, an air escape vent in the return line, and a thermostatic valve controlling said vent and adapted to permit escape of air and to prevent escape of steam.

3. A vapor heating system comprising in combination a boiler, a steam line, a return line, a radiator in communication with said lines, and a differential loop embodying two separate chambers one above the other, a connection from the upper chamber to the return line, a connection from the lower chamber to the boiler, and two pipes passing between the chambers, one of said pipes having an opening at a height above the bottom orifice of the other pipe arranged in a plane other than horizontal, whereby it is more or less uncovered by lower or higher levels of the water in the lower chamber.

4. A vapor heating system comprising the combination of a boiler, a steam line, a return line, a radiator in connection with both of said lines, a differential loop having an inlet connected with the boiler and an outlet connected with the return line, said loop including also water legs in communication with the inlet and the outlet and an equalizing pipe forming a by-pass from the leg into which said inlet opens to the leg into which said outlet opens, the return line having a vent to the atmosphere in close proximity to the outlet from said loop, and a thermostatically controlled valve connected to said vent and adapted to be closed by the temperature of live steam when steam flows through said equalizing pipe to the steam line.

5. A vapor heating system comprising in combination a boiler, a steam line, a return line, a radiating element in communication with said lines, and a differential loop comprising a casing having a transverse partition dividing the same into an upper chamber and a depending leg, and having an inlet below said partition connected with the boiler and an outlet above the partition from the upper part of said chamber connected with said return line, a balancing pipe fixed in said partition passing through the same and extending downwardly into said leg and having an open end, and an equalizing pipe also passing through said partition and extending into said leg, having inlet means above the level of the bottom of the balancing pipe and arranged to have its effective area enlarged or diminished by descent and rise, respectively, of the water in said leg.

6. A vapor heating system as claimed in claim 5 distinguished by the fact that the inlet in said equalizing pipe is formed by an elongated opening through the side of said pipe.

7. A vapor heating system as claimed in claim 5 distinguished by the fact that the inlet in said equalizing pipe is a slot cut through the wall of the pipe upwardly from the lower end thereof.

8. A vapor heating system as claimed in claim 5 distinguished by the fact that the balancing pipe is nearer that side of the casing into which the inlet to the loop opens and the equalizing pipe is nearer that side of the casing through which the outlet opens.

9. A vapor heating system comprising the combination with a boiler, a steam line, a return line and heat radiating means in communication with said lines, of a water containing loop between said lines and comprising two legs connected together at a low level and connected, at relatively higher levels, one with the boiler and the other with the return line, the connection between the boiler and loop being so arranged that water condensed in such connection is caused to pass through the loop into the return line and so maintain a given maximum height of water in that leg which is connected to the return line, said loop also comprising a by-pass extending from that leg which is connected to the boiler, being connected with said leg at a level above the connection between the two legs and opening to the return line at a height above the water level in that leg which is connected to the return line.

10. A vapor heating system comprising the combination with a boiler, a steam line, a return line and heat radiating means in communication with said lines, of a loop comprising legs connected together at a low level and connected at higher levels with the boiler and the return line, respectively, an equalizing by-pass having a relatively low inlet in the leg which is connected to the boiler and a relatively high outlet in the leg which is connected to the return line, said inlet being so formed and arranged that it is opened to a greater or less area in proportion to the extent of depression of the surface of the water column in the leg whereto said inlet opens.

11. A vapor heating system comprising the combination with a boiler, a steam line, a return line and heat radiating means in communication with said lines, of a differential loop adapted to maintain a pressure differential between the said lines, and comprising a leg connected to the boiler to receive condensation of steam and comprising also a second leg connected to the return line at a point such that the water therein is able to overflow to the return line and the maximum height of the water leg therein is established by such overflow, and a by-pass connection leading from a relatively low point in that leg which is connected to the boiler to a point of discharge into the return line at a relatively higher level.

12. A vapor heating system comprising a boiler, a radiator, a steam line connected to conduct steam from the boiler to the radiator, a return line connected to conduct water of condensation from the radiator to the boiler, a differential loop having an inlet connected to receive steam from the boiler and an outlet connected to the return line, said loop being constructed with water legs connected to one another at their lower ends, the water columns in which legs are exposed at their heads to the pressures existing in said inlet and said outlet, respectively, and the loop comprising further a by-pass from a relatively low level in that water leg which is exposed to the inlet pressure, to a relatively higher level in that leg which is exposed to the outlet pressure; combined with a vent to the atmosphere from the return line and a thermostatic valve controlling said vent and constructed to be closed by the heat of live steam and to be opened by cooling to a temperature lower than that of steam, said vent and valve being in close proximity to the outlet from the loop.

In testimony whereof I have affixed my signature.

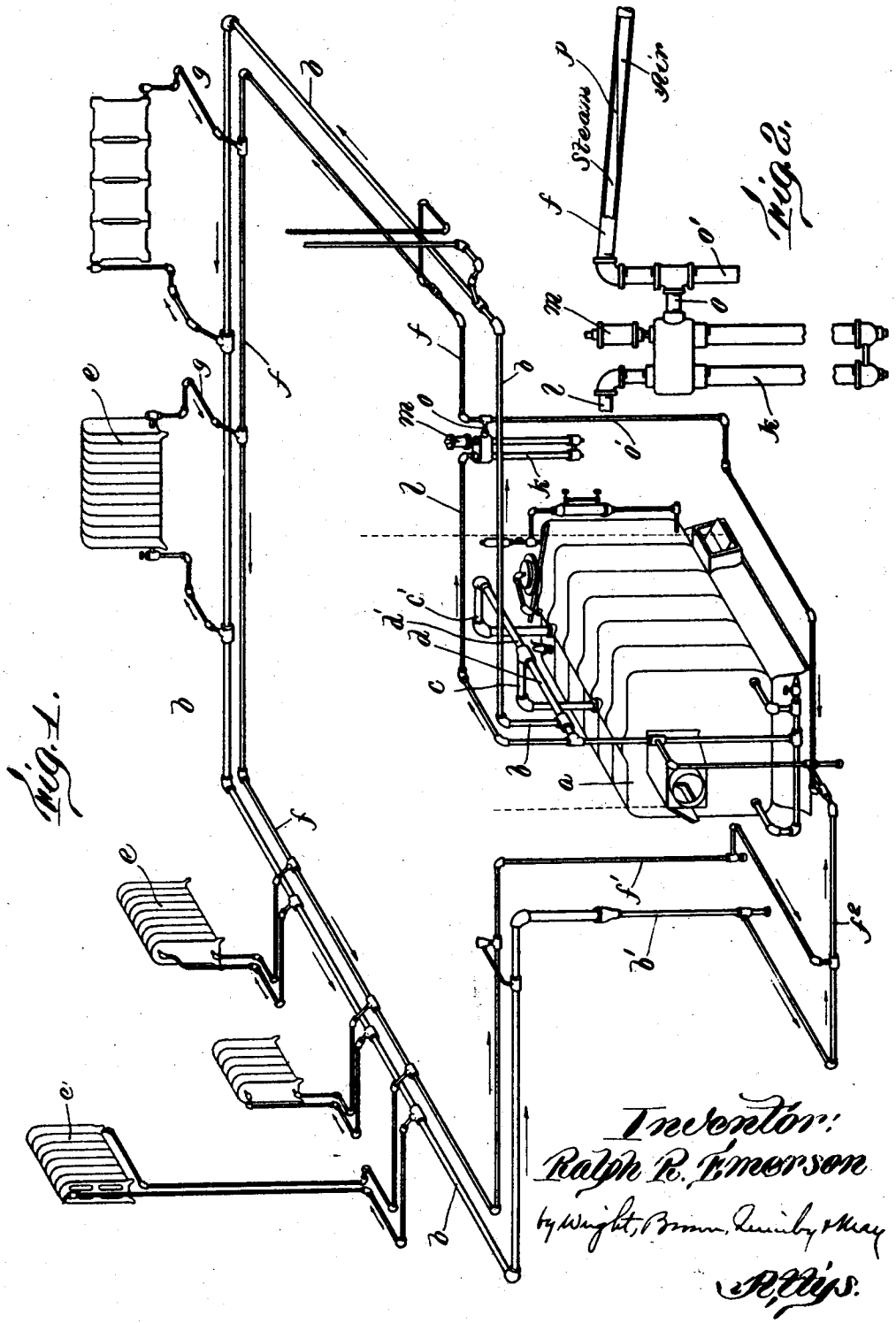
GEORGE D. HOFFMAN.

Aug. 16, 1927. 1,639,084

R. R. EMERSON

HEATING SYSTEM

Filed Dec. 3, 1925



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Patented Aug. 16, 1927. 1,639,084

UNITED STATES PATENT OFFICE.

RALPH RAY EMERSON, OF BROOKLYN, NEW YORK, ASSIGNOR TO HOFFMAN SPECIALTY COMPANY, OF WATERBURY, CONNECTICUT, A CORPORATION OF ILLINOIS.

HEATING SYSTEM.

Application filed December 3, 1925. Serial No. 72,964.

The present invention relates to low pressure heating systems equipped with automatic means for causing or permitting steam to pass from the pressure side of the system to the return line, directly and without first passing through the radiators, whenever the boiler pressure rises above a predetermined degree. By the term "pressure side of the system," or equivalent terms, as used in this specification, I mean the boiler or any part of the steam supply main, or connection between the boiler and the supply main. The means for permitting direct passage of steam from the supply line to the return line, referred to above, include such devices as the differential loops disclosed in the Letters Patent of the United States to George D. Hoffman, No. 1,572,482, granted February 9, 1926, and entitled "Vapor heating system with differential loop," and the application for such Letters Patent filed by William K. Simpson, September 30, 1925, Serial No. 59537, entitled "Differential loop for heating systems," as well as other means or apparatus adapted to serve essentially the same purpose as such loops. In this specification I will call such means by the term "steam crossover device." intending by that term to include any apparatus which will operate to admit steam into the return line and so prevent water being forced out of the boiler into the return line when the boiler pressure becomes abnormally high, as explained in said applications.

The present invention does not involve any new principles or construction in such a steam crossover device, but is concerned only with a new mode of combination or application of such a device with and in a low pressure steam heating system; and the new step of the invention consists mainly in providing the system with a dry return line, and in connecting the loop, or equivalent crossover device with the dry return line at or near the highest point thereof. This point of connection, and its location, may be designated generically as the "high point" of the return line, meaning by that term not necessarily the absolutely highest point, but one sufficiently near the absolutely highest point for the purposes of this invention and the results to be obtained as hereinbefore explained. Preferably the dry return line is arranged with its highest point as near as practicable to the boiler, and running thence on a downward pitch to a connection with a wet return line which enters the lower part of the boiler; and said dry return line makes a circuit of the building in such fashion that it may be connected with the return outlets of the various radiators or heating coils. The term "dry return line" does not mean that the line so called contains no water, but signifies that it is so high above the normal water level of the boiler, and so large, that the water of condensation entering it from the radiators will run off without filling it, except possibly for very brief periods.

In further explanation of the invention attention is directed to the drawings furnished herewith, in which;

Figure 1 is a perspective view of a steam heating system of the sort to which my invention is applicable, and having therein a dry return line and a differential loop connected to the high point of the return line;

Figure 2 is a fragmentary view of the highest part of the return line and the loop or crossover device connected therewith, illustrating graphically the action which takes place as a result of so connecting the loop with the return line.

Like reference characters designate the same parts in both figures.

The above mentioned Figure 1 represents a typical installation containing the present invention, in which a is a steam boiler, b is the steam line or supply main connected with the boiler by communicating pipes c, d and c', d'; the two latter comprising what is commonly termed "a boiler header." e—e are radiators or heating coils and f is the dry return line. Such return line makes a circuit of the building in which the heating system is installed, running generally parallel to the steam line, so that it may be connected by return connections g with the radiators which are connected by supply connections with the steam line. Both steam line and the dry return line extend with a downward pitch from their ends nearest the boiler to their ends at the termination of the circuit of the building, and at their latter ends are connected by descending legs b' and f', respectively, with the wet return line f^2 which is connected with the boiler in a suitable fashion for permitting water of condensation to return thereto.

The letter k represents a steam crossover

device of the type known commercially as the "Hoffman differential loop," the preferred construction of which is shown in the aforesaid application of William K. Simpson, and the principles of which are more particularly explained in the aforesaid Hoffman patent. Therefore no detailed illustration of such loop is necessary here. It is sufficient for present purposes to say that the loop is connected with the return line and the steam side of the system, the latter connection being made by a pipe *l*, and that it is constructed with two legs containing water columns connected together at their bottoms, one of which legs is connected at its top with the return line, and the other at its top to the steam connection *l*, and a by-pass extends from the lower part of the latter leg to the upper part of the former leg arranged to be uncovered by descent of the water column therein so as to permit passage of steam directly from the steam side of the system to the return line when such water column is sufficiently depressed by steam pressure. By virtue of these characteristics, whenever the steam pressure in the boiler rises to such a degree as would otherwise cause the water to back up into the return line in volume sufficient to uncover surfaces in the boiler which are exposed to intense heat and should always be covered with water, then steam is admitted to the return line up to a sufficient pressure to oppose and prevent such backing up of the boiler water. All this is fully explained in the prior patent aforesaid and is repeated here simply to make clear the purpose and utility of such loop, or equivalent device for allowing steam on occasion to pass directly from the steam side of the system to the return line. The same function and effect may be performed by specifically different means than the Hoffman differential loop; wherefore, since my invention is not concerned with the details of such loop or any improvement therein, neither is it restricted to said loop or any other specific crossover device. There is connected with the crossover device, or with the return line near such device, an automatic thermostatic valve *m* which is normally open to the atmosphere when the boiler pressure is no higher than that prescribed as the normal pressure for causing circulation of steam, but is closed by thermostatic action when live steam reaches it after passing the loop, in order to prevent loss of steam.

In accordance with my invention I connect the loop or equivalent steam crossover device with the return line at the highest part of the latter; in other words at the high point of the return line, according to the definition of the term "high point" previously given. This connection is shown at *o* in the drawing; and as there shown is made through an upright pipe *o'* which runs from the high part of the line to a connection with the wet return line in order to lead directly back to the boiler any water which may overflow from the loop. Preferably this point of connection is so near the boiler that the steam connection to the loop may be so short as to reduce as much as possible the condensation and pressure loss of steam flowing to the loop.

As a result of connecting the loop at this point, the steam which enters the return line from the loop is above the air already in the return line. It is to be understood that at such times the return line is full of air because the thermostatic valve is normally open, and also because air passes into the return line from the radiators when steam is turned into the latter. Thus when steam passes into the return line through the loop, it can only penetrate the line until it has compressed the air already therein to an equal pressure. As the line is laid with a downward pitch, and as steam is lighter than air, a definite demarkation plane is established at some point in the return line, as designated graphically at *p* in Figure 2; all the space in the line lower than this plane being filled with air, and the space in the line above the plane being filled with steam. The particular location along the length of the line in which this plane is found depends on the steam pressure and the downward pitch of the return main and will be different at different times and under different conditions. But this is unimportant. The important fact is that when steam enters the return line it forces and compresses the air ahead of it, but can only penetrate the line to the point where it has compressed the air to equal pressure. Another important fact is that the flow of steam in entering the return line takes place in the same direction as the flow of water of condensation passing from the radiators to the wet return line.

When the crossover device is connected to a low part of the return line, steam admitted by such device is able to pass the air previously in the line and to flow in the opposite direction to the water flowing downward through the line, retarding and backing up the water and causing noise or water hammer. As a result of my new combination and arrangement there is no noise when steam flows into the return line because it does not blow back the water of condensation and cause it to form slugs of water obstructing the pipe. The distance to which steam can enter the return line is limited and there is less condensation of steam and therefore the condition of equilibrium which prevents further influx of steam is reached more quickly. When the automatic valve is opened and the heating system is being relieved of air, the path of the outflowing air is upward toward the automatic

relief valve, wherefore the air escapes more easily, quickly and completely.

By the use of this invention an increased flexibility in laying out heating systems is made possible; because the high point in the dry return line can be carried above the high point in the steam main; always providing, of course, that the high point in the return line is lower than the traps on the radiators. Thus in a situation where there would normally be a very small waterline difference, if laid out according to previously accepted standard principles, it is possible with the use of this invention to increase the waterline difference by carrying the return main above the steam main.

The connection of the crossover device with an upright pipe, and with a step or jump up from said device to the dry return line, as shown in the drawing and previously described, is for the purpose of allowing water which issues from this device to return directly to the boiler without traveling all the way along the dry return line. This arrangement is not essential, however, and in some installations the crossover device is connected to the absolutely highest point in the dry return line, without a direct downward or drip connection to the wet return line.

This invention is applicable to all low pressure steam heating systems, including both the so-called vapor and vapor vacuum systems. The only difference between the two systems thus identified is in the character of the valve *m*: that used with vapor systems being normally open except when steam passes the crossover device, and that used in the vapor vacuum systems being closed by an additional check valve which prevents entrance of air from the atmosphere when the steam pressure in the system is below the atmospheric pressure. But in all these systems the function and effect of the loop or other crossover device is the same.

The appended claims are to be construed in the light of the definitions hereinbefore given, and particularly with the understanding that the foregoing specific description of details of construction is illustrative or representative and not matter of limitation.

What I claim and desire to secure by Letters Patent is:

1. In a low pressure steam heating system a boiler, a steam line and a dry return line, a steam crossover device connected to the steam side of said system and to the high point of the return line, and a drip connection from said device to the low part of the return line.

2. In a heating system a steam boiler, a steam line, a dry return line having a downward pitch and a return connection to the boiler from its lower end, and a steam crossover device coupled with the steam side of the system and having a discharge outlet connected upwardly to the highest part of the dry return line, and downwardly to the wet return line.

3. In a steam heating system, a boiler, a steam line, a dry return line arranged with a downward pitch, a wet return line leading from the lower end portion of said dry return line to the lower part of the boiler, a steam crossover device connected to receive steam from the steam side of the system and having a steam outlet, and a thermostatic valve opening to the outer atmosphere, said outlet and said thermostatic valve both being in connection with the dry return line near the highest point of such line.

4. In a steam heating system, a dry return line and a steam crossover device between said line and the pressure side of the system, said crossover device being connected with the dry return line at the high point of the latter.

5. In a steam heating system, a boiler, a steam line, a dry return line extending in approximate parallelism with said steam line and with a downward pitch, heating units connected to said steam and return lines, a steam crossover device connected to receive steam from the boiler, and a pipe in connection with the outlet side of said crossover device extending upwardly to connection with the high point of the dry return line and downwardly into connection with the lower part of the return line.

In testimony whereof I have affixed my signature.

RALPH RAY EMERSON.

Oct. 7, 1930. W. K. SIMPSON 1,777,333

DIFFERENTIAL LOOP FOR HEATING SYSTEMS

Filed Sept. 30, 1925

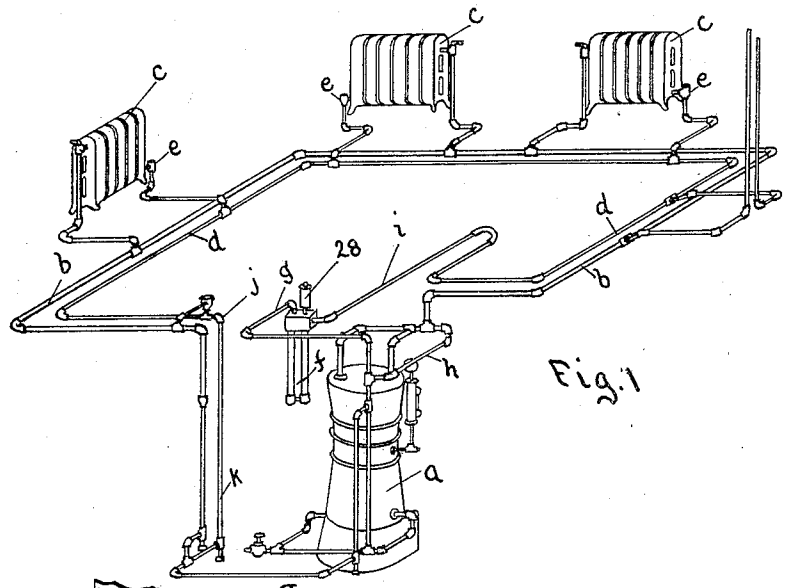

Fig. 1

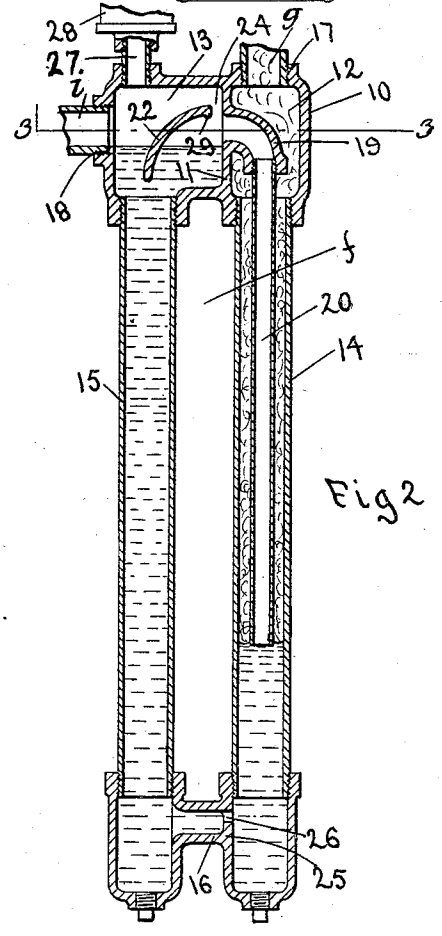

Fig 2

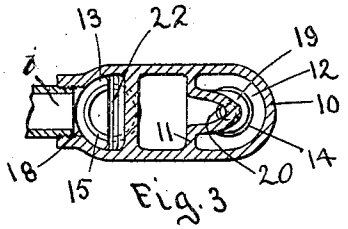

Fig. 3

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Attys

Patented Oct. 7, 1930

1,777,333

UNITED STATES PATENT OFFICE

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DIFFERENTIAL LOOP FOR HEATING SYSTEMS

Application filed September 30, 1925. Serial No. 59,537.

The present invention relates to automatic valveless pressure regulators for heating systems, designed and adapted to permit transfer of steam from the steam line, or high pressure side of the system, to the return line, or low pressure side of the system, whenever the pressure in the boiler, or high pressure side, exceeds a predetermined value, while at the same time maintaining a difference of pressure between the two sides of the system.

The object of the invention is to provide a regulator of a construction the parts of which may be simply and accurately made and assembled, and which can be installed readily in any system of the types to which it is applicable.

The invention comprises the device and combination hereinafter particularly described, in the embodiment so described and in all equivalents thereof, within the scope of the appended claims.

Regulators of the type herein disclosed have been given the descriptive name of "differential loop," in commercial practice; and I will use that same name in the following detailed description of my improved regulator.

In the drawings,—

Figure 1 is a diagrammatic view showing a heating system equipped with my differential loop.

Figure 2 is a vertical section of the loop apart from the system and shown on a larger scale.

Figure 3 is a cross section of the loop on line 3—3 of Figure 2.

Referring first to Figure 1 in explanation of the utility of the invention and the environment in which it is used, the letter *a* designates a steam boiler, the letter *b* designates the steam supply pipe of a heating system, *c*, *c* designate radiators, and *d* represents the return pipe. *e* represents thermostatic return valves connected to the radiators and through which water of condensation and entrapped air are allowed to flow freely to the return pipe or line but which close automatically to prevent live steam so flowing.

f represents my differential loop. It is connected by means of suitably arranged pipes *g* and *h* with the steam pipe or line, and thereby with the steam space of the boiler, and by means of a pipe *i* with the return line. The steam line and steam space of the boiler constitute the high pressure side of the heating system, while the return line constitutes the low pressure side of the system.

As here shown, the return line runs from a high point near the boiler, on a gradual downward inclination in a circuit of the building in which the heating system is installed, and at a level wholly above the boiler water level, as far as a point *j*, also near the boiler. This part of the return line normally is practically empty of water, containing only the condensate returning to the boiler, which never fills it, and is called the "dry" return. A descending pipe *k*, connected to the dry return line at *j* and constituting what is called the "wet" return line, carries the accumulated water of condensation to the boiler, and water normally rises therein to a height which will balance the boiler pressure. The loop is preferably connected to the high end of the return line. This layout of the return line, and the idea of connecting the loop to the high end of such line are the invention of Ralph R. Emerson of Brooklyn, N. Y., patented by him August 16, 1927, No. 1,639,084 and I do not claim them herein; but I have shown them as representing the best mode known to me of installing the loop, in which my invention resides, in a heating system.

Referring now to Figures 2 and 3, which show the preferred structure of the loop in detail, such structure comprises a box or casing 10 having a partition 11 which divides it into two chambers 12 and 13; upright pipes 14 and 15 secured to the casing in communication with openings in the bottoms of the chambers 12 and 13 respectively, and a coupling 16 joining the lower ends of said pipes. Generically, the loop as a whole is a U-tube, of which the pipes 14 and 15 are the legs, the coupling or fitting 16 is the bottom, and the chambers 12 and 13 are the heads of the legs. The members or fittings thus designated as the casing 10 and coupling 16 may be made

as castings of iron or other suitable metal, and the pipes 14 and 15 may be cast or drawn tubes threaded and screwed into the openings provided, substantially as shown, in the fittings 10 and 16. The steam connection *g* is screwed into an entrance opening 17 in the top of the chamber 12, and the return line connection *i* is screwed into an opening 18 in the side of the chamber 13.

There is formed integral with the partition 11 an elbow conduit 19 which terminates within the chamber 12 in an orifice in substantially axial alinement with the bottom opening which receives the pipe 14, and to this elbow conduit there is attached, by being screwed into it, an interior pipe 20 which extends downwardly in pipe 14 part way to the lower end of the latter. This pipe and the elbow fitting 19 constitute an equalizing pipe, so called because it is adapted to perform an equalizing function as presently described.

In the chamber 13 and opposite to the upper orifice of the elbow connection 19 is a curved baffle 22 which extends entirely across the chamber from side to side and lies on an inclination between the connection 19 and the return line connection 18. Its purpose and effect is to deflect water issuing from the connection 19 toward the pipe 15 and to prevent outflow of such water through the return line connection 18. Adjacent to the upper end of the baffle 22 is an opening 24 so arranged that steam flowing through the elbow connection may pass readily over the baffle to the return line connection 18.

It will be noted that the coupling or connection 16 between the lower ends of the pipes is partly blocked by a wall 25, and that there is a restricted passage 26 through said wall.

The chamber 13 has a connection 27 in its upper wall on which is mounted a combination valve 28 containing a thermostatic outlet valve constructed to permit outflow of air, but having a thermostat which closes the valve to prevent outflow of steam, a float which closes the valve to prevent outflow of water and a vacuum valve which closes to prevent inflow of air when the pressure in the heating system drops below the atmospheric pressure.

When the loop is connected in a heating system as described, it contains water to a height at least sufficient to seal the lower end of the pipe 20. The water for this purpose may be poured into the loop before installation or it may be allowed to collect by condensation of steam in the connection *g* and in the loop itself. At any rate while the system is in operation a sufficient supply of water will be maintained by condensation to seal the pipe 20.

When the pressure in the boiler is higher than the return line pressure, the water level in the pipe 14 will be depressed and water will be transferred into the pipe 15 until the difference of levels balances the excess boiler pressure.

If, by reason of rising pressure in the boiler, the water level in pipe 14 should be depressed below the lower end of pipe 20, steam will pass through this pipe and the chamber 13 into the return line and create a pressure there which is equal to the difference between the boiler pressure and the pressure head of the water leg in pipe 15 above the lower end of pipe 20. The absolute value of this pressure difference is determined by the vertical distance to which the pipe 20 descends below the level of the return line connection 18. No matter how high the boiler pressure may rise, the transfer of steam to the return line, which is permitted by the loop, causes the return line pressure to undergo a parallel rise, but the pressure head of the water column in pipe 15 always maintains a pressure difference between the boiler and the return line.

Upon subsidence of the boiler pressure the combined action of the return line pressure and the pressure head in pipe 15 causes the water to rise in pipe 14 and seal the pipe 20 so that steam can no longer pass through the loop until either the boiler pressure rises again or the return line pressure is diminished by condensation of steam therein.

Ordinarily it is intended that the systems in which the loop is used shall be operated with a boiler pressure not exceeding the water head capable of being created in the loop, such water head being the prescribed maximum differential between the boiler and the return line pressures; and when the system is thus operated, no steam will pass through the loop, but the water levels in the two legs thereof will assume positions such that the excess head in leg 15 balances the boiler pressure. Only when abnormally high pressures occur in the boiler, or abnormally low pressures occur in the return line, will the loop allow steam to pass. The pressure then developed in the return line by such transfer of steam prevents any danger of water backing up into the return line and so leaving the boiler.

The thermostatic valve 28, being directly contiguous to the chamber 13 which is filled with steam as soon as steam begins to flow through the loop, is instantly closed by the steam then flowing, so that the pressure in the return line begins at once to rise. But when air in the return line reaches the thermostatic valve, or when the steam in the return line condenses, this valve is opened, while the associated vacuum valve will be opened if there is air in the return line at a pressure higher than atmospheric, or remain closed if there is a vacuum in the return line.

The loop having the construction and characteristics above described, or the equivalent thereof, has the following features of advantage among others. The baffle 22 pre-

vents water from leaving the loop when steam flows through it. When the water in the pipe 14 is forced below the pipe 20 and steam enters the latter the steam has a strong tendency to pick up and carry water with it through the pipe 20, and it does thus carry a substantial quantity of water. But the water thus entrained, when discharged from the connection 19, strikes the baffle 22 and is thereby deflected toward the pipe 15. At the same time the steam is allowed to pass through the opening 24, so that there is practically a complete separation between steam and water at this point. Such separation is assisted by a narrow ledge 29 at the entrance to the steam passage 24. Steam, therefore, passes readily through the loop, but substantially all of the water is retained and preserved except that which, as a result of long accumulation, may pass by overflow through the return line connection. The important fact in connection with the baffle is, however, that it prevents water from being taken out of the loop by entrainment with steam, and so prevents the loop from becoming inoperative by loss of water.

The restriction 26 in the lower part of the loop retards the return flow of water from the leg 15 into the leg 14. The volume of flow through this restricted orifice is less than the volume of water which can be carried by entrainment with steam through the pipe 20. Thus immediately after the flow of steam begins through pipe 20 the water level in the leg 14 is lowered to a point at which there is a minimum of entrainment, and it is maintained at such a low point until the increasing back pressure on the water column in pipe 15, acting in conjunction with the diminished flow of steam, causes the water in leg 14 to rise and again seal the pipe 20. In short, the restriction prevents the steam flow from setting up a circulation of water through the loop and diminishes the quantity of water required to be separated by the baffle.

What I claim and desire to secure by Letters Patent is:

1. A loop as and for the purposes set forth comprising a U-tube, a head having two chambers each connected with one of the legs of said tube, a steam connection to one of said chambers, an outlet connection from the other of said chambers, and an equalizing pipe extending within the upper part of that leg which is connected to the chamber having the steam connection, said equalizing pipe being connected to discharge laterally into the other chamber.

2. A loop as and for the purposes set forth comprising a U-tube, a head having two chambers each separately connected with one of the legs of said tube, a steam connection to one of said chambers, an outlet connection from the other of said chambers, an equalizing pipe extending within the upper part of that leg which is connected to the chamber having the steam connection, said equalizing pipe being connected to discharge laterally into the other chamber, and a baffle in the last-named chamber between the outlet of said equalizing pipe and the outlet from said chamber, to deflect water issuing from the equalizing pipe toward the leg which is connected to said last-named chamber.

3. A loop as and for the purposes set forth comprising a head having an internal partition dividing it into two chambers, legs forming a U-tube connected respectively to the bottom parts of said chambers, one of said chambers having a steam connection and the other having an outlet connection, an equalizing pipe located in one of said legs and opening into the chamber which has said outlet connection, and a baffle in the latter chamber between said equalizing pipe outlet and said outlet connection, with a steam passage between the highest part of the baffle and the equalizing pipe outlet, and a water space beneath the baffle open to the leg which is connected to said last-named chamber.

4. A differential loop comprising a head, legs leading downward from said head, said head being internally divided into two chambers, one of which has a steam inlet and the other an outlet, an equalizing pipe leading from a relatively low point in that leg which is connected to the chamber having the steam inlet and arranged to discharge into the other chamber, and a loop bottom connecting the lower ends of the legs and having a restricted flow passage of less capacity than the water conducting capacity of said equalizing pipe.

5. A differential loop comprising legs connected together adjacent to their lower ends, a steam connection to the head of one of said legs, a steam and water outlet connection to the head of the other leg, and an equalizing pipe opening at a low point in the leg first above specified and leading thence to the head of the other leg, the connection between said legs having a flow capacity less than that of the equalizing pipe.

6. A differential loop comprising a leg adapted to be connected at its upper end with a steam source, a second leg having an outlet at its upper end, an equalizing pipe leading from the upper end of the second leg into the first leg and having an opening within said first leg at a level below said outlet, and a connection between the legs below the opening of the equalizing pipe having a flow capacity substantially less than that of the said pipe.

7. A differential loop comprising a leg adapted to be connected at its upper end with a steam source, a second leg having an

outlet at its upper end, and equalizing pipe leading from the upper end of the second leg into the first leg and having an opening within said first leg at a level below said outlet, a baffle in the second leg between said outlet and the point where the equalizing pipe opens into the leg arranged to separate water from steam issuing from the equalizing pipe, and a connection between the two legs at a point below the opening of the equalizing pipe in the first leg having a flow capacity less than that of the equalizing pipe.

8. A differential loop comprising an upright U-tube, a steam inlet to the head of one of the legs of said U-tube, a steam and water outlet from the head of the other leg of said U-tube, an equalizing pipe leading from a low point in the first leg into the head of the other leg, and means for separating water from steam issuing into the second leg from the equalizing pipe.

9. A differential loop comprising a head having an intermediate upright partition dividing it into two chambers, legs connected with and extending downwardly from the bottom of the respective chambers and connected to each other near their lower ends, a conduit opening from one of said chambers and leading through the other chamber downwardly into the leg connected thereto and opening into such leg, and a baffle crossing the first named chamber from a point adjacent to but separated from and above the orifice of said conduit on a downward and outward inclination therefrom toward the bottom of the chamber; said first chamber having an outlet and the second mentioned chamber having an inlet.

In testimony whereof I have affixed my signature.

WILLIAM K. SIMPSON.